Rev 4

CREDIT FOR ACCIDENT PRESSURE IN CALCULATED NPSH FOR ECCS AND CONTAINMENT HEAT REMOVAL PUMPS

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a/w

Purpose of Briefing

TO INFORM THE EDO OF THE STATUS OF THE THIS ISSUE

TO OBTAIN CONCURRENCE WITH (1) THE PROPOSED POSITION FOR FUTURE REVIEWS, AND (2) PROPOSED ACTIONS

Definition of Available NPSH

$$\text{NPSH AVAILABLE} = h_{ATM} + h_{STATIC} - h_{LOSSES} - h_{VAPOR}$$

where

h_{ATM} = pressure of containment atmosphere

h_{STATIC} = pressure due to height of water above pump suction

h_{LOSSES} = pressure losses in piping, fittings, and screens

h_{VAPOR} = vapor pressure of pumped fluid

NRC Guidance On NPSH

Some reactors licensed with overpressure credit

1970 Regulatory Guide 1.1 Guidance on NPSH

> ....adequate NPSH is provided to system pumps assuming maximum expected temperatures of pumped fluids and no increase in containment pressure from that present prior to postulated LOCAs.

1974 Regulatory Guide 1.82 Guidance on PWR Sump Design

> The available surface area in determining the design coolant velocity [at the entrance to the sump screen] should be based on one-half of the free surface area of the ... inner screen... **(Non-conservative)**

NRC Guidance On NPSH (CONT.)

1981 SRP 6.2.2 Rev 4 Containment Heat Removal Systems

for BWRs: $h_{atm} = 0$
for PWRs: $h_{atm} = h_{VAPOR}$, or,
$h_{atm} = 0$

"NPSH analysis will be acceptable if it is done in accordance with ...Regulatory Guide 1.1, i.e., is based on maximum expected temperature of the pumped fluid and with atmospheric pressure in containment."

SRP 6.2.2 allows overpressure credit for subatmospheric containments during the first hour following a LOCA.

NRC Guidance On NPSH (CONT.)

1985	GL 85-22	(GSI A-43) LOCA Debris Guidance h_{loss} increases No backfit; consider for modifications Regulatory Guide 1.82 Rev 1 Issued. Fibrous insulation debris should be considered as uniformly distributed over the available debris screen area Did not address containment conditions assumed in determining NPSH, only design of sumps and ECCS suction strainers

NRC Guidance On NPSH (CONT.)

1996 BULLETIN 96-03 BWR ECCS STRAINER BLOCKAGE
h_{loss} increases

Result of the 1992 Barsebäck event (strainer blockage).
BWRs should Install suction strainers. Results in greater pressure losses
Increased suction losses due to larger strainers and consideration of debris

NRC Guidance On NPSH (CONT.)

1997	GL 97-04	Request for information on NPSH calculations for containment heat removal and ECCS pumps including credit for containment overpressure. BWRs and PWRs. Prompted by credit for overpressure w/o prior NRC review and approval. Reviews of all operating reactors performed. Criteria developed for the review allowed credit for containment overpressure. These criteria were not documented at this time.

NRC Guidance On NPSH (CONT.)

All BWR NPSH calculations revised as a result of Bulletin 96-03. Some BWRs received credit for overpressure. Some BWRs licensed with credit for overpressure and the credit for overpressure was increased. Some BWRs did not need overpresssure in order to comply with Bulletin 96-03.

2003	Bulletin 2001-03	Guidance on PWR Sump Blockage
		Some PWR licensees may request credit for containment overpressure to compensate for higher head losses

RG 1.82 Rev 3 Guidance

(*Words in italics to be modified*)

ECCS and containment heat removal systems should be designed so that sufficient available NPSH is provided to system pumps *assuming maximum expected temperature and no increase in containment pressure from that present prior to LOCA* (Same as RG 1.1)

For certain operating reactors *for which the design cannot be practicably altered*, conformance with the previous position may not be possible. *In these cases, no additional containment pressure should be included in NPSH analyses than necessary to preclude pump cavitation.*

For certain operating reactors *for which the design cannot be practicably altered*, credit may be taken for pump tests which demonstrate that a cavitating pump will continue to deliver the design basis flow rate. The time period is no longer than that of the test.

Approved by ACRS

Postulated Accidents for which Overpressure Credit Has Been Allowed

LARGE BREAK LOCA
ATWS
STATION BLACKOUT
APPENDIX R SAFE SHUTDOWN FIRE

Reactors Which Have Received Overpressure Credit

Beaver Valley Unit 1 (PWR)
Browns Ferry Units 2 and 3 (BWR Mark I Containment)
Cooper (BWR Mark I Containment)
Dresden Units 2 and 3 (BWR Mark I Containment)
Duane Arnold (BWR Mark I Containment)
FitzPatrick (BWR Mark I Containment)
Fort Calhoun (PWR)
Hatch Units 1 and 2 (BWR Mark I Containment)
Monticello (BWR Mark I Containment)
North Anna Units 1 and 2 (PWRs)
Oconee Units 1, 2 and 3 (PWRs)
Oyster Creek (BWR Mark I Containment)
Peach Bottom Units 2 and 3 (BWR Mark I Containment)
Pilgrim (BWR Mark I Containment)
Quad Cities Units 1 and 2 (BWR Mark I Containment)
Surry Units 1 and 2 (PWRs)

Conservatisms In NPSH Calculation

. Pumps are not high suction energy pumps. Therefore, operation in cavitation for the times of interest should not damage pump.

. No credit is taken for the decrease in required NPSH as the water temperature is increased. The required NPSH is measured cold and the suppression pool water temperature is in the range of 170-200 F.

. Reactor is assumed to be operating at 102% of licensed thermal power. (Increase h_{VAPOR})

. A 2σ value of decay heat is used. (Increase h_{VAPOR})

Conservatisms In NPSH Calculation (CONT.)

. Feedwater flow into the vessel is assumed to continue until all feedwater which will increase the peak suppression pool temperature is injected into the vessel. This is conservative because the assumption is made that off-site power is lost at the beginning of the LOCA. (Increase h_{VAPOR})

. All the water mass in the vessel and the attached piping up to the isolation valves is assumed to be at saturation temperature. Actually, there is considerable subcooling. (Increase h_{VAPOR})

. The torus is assumed to be perfectly insulated so that there is no heat transfer from the torus to the reactor building. Heat transfer to metal structures in the torus is also not included. (Increase h_{VAPOR})

. 100% of the rated horsepower of the ECCS pumps is assumed to be converted to pump heat and added to the suppression pool water. (Increase h_{VAPOR})

Conservatisms In NPSH Calculation (CONT.)

. Decay heat values are input manually to the code with an input table and not calculated at each time step. Interpolation between points results in an increase in the total energy added to the suppression pool. (Increase h_{VAPOR})

. RHR heat exchanger performance is calculated assuming maximum fouling (over the 40 year life) and tube plugging levels. (Increase h_{VAPOR})

. The technical specification (limiting) service water temperature is assumed. (Increase h_{VAPOR})

. The initial suppression pool water volume is the minimum technical specification value. This maximizes the suppression pool temperature and the air volume above the suppression pool which minimizes the torus pressure. (Increase h_{VAPOR})

. The ECCS pump flows are overestimated which conservatively maximizes the required NPSH. Also increases h_{LOSSES}, decreases h_{VAPOR}.

Conservatisms In NPSH Calculation (CONT.)

. Containment sprays are assumed operating. They are initiated by operator action at 600 seconds and are operated continuously with no throttling of the LPCI/service water pumps below the initial spray flow rate. (Decrease h_{ATM})

. The design basis pressure drop across the ECCS pump suction strainers due to LOCA-generated debris is included. This assumes that the pipe break is at the location which yields the maximum debris relative to any other location in containment and that this debris is transported efficiently to the suppression pool and then to the strainers. (Increase h_{LOSSES})

. The initial air mass in containment is minimized. This minimizes the resulting containment accident pressure. This is done by minimizing the initial containment conditions. (Decrease h_{ATM})

. Worst single failure. (Increase h_{VAPOR})

Conservatisms In NPSH Calculation (CONT.)

. Credit is taken for containment leakage to reduce the containment pressure. (Decrease h_{ATM})

. Break flow is underestimated. (Decrease h_{ATM})

. The initial suppression pool temperature is at the maximum technical specification value (typically 95 F) to maximize the calculated suppression pool temperature. (Increase h_{VAPOR})

Risk Consideration

A risk calculation is performed using realistic input values and assumptions.

Vermont Yankee personnel indicate that when using realistic input and assumptions, no credit for containment overpressure is required.

Therefore, the licensee states that the risk increase is negligible.

Risk Consideration (Cont)

A staff calculation using the VY IPE and SPAR model calculated the change in CDF given that containment pressure is required

This was determined as

(Large LOCA frequency)(Probability of failure of containment isolation)

It was assumed that loss of overpressure is equivalent to loss of ECCS pumps and therefore core damage.

$\Delta CDF = 1.3E\text{-}07 = \Delta LERF$

THIS IS SMALL AND ACCEPTABLE ACCORDING TO RG 1.174

Proposed Modified Position

Credit for overpressure is allowed when a conservative calculation demonstrates that sufficient containment pressure is available

No test of "necessity" or specific cause of the NPSH deficiency is part of the criteria for allowing credit for containment overpressure.

No limit is placed on the amount of pressure that may be assumed available as long as the pressure is determined conservatively.

Risk considerations to be determined as part of Vermont Yankee review.

Plan For Re-evaluating Credit For Containment Accident Pressure

1. Withdraw RG 1.1

2. Modify RG 1.82 Rev 3 to reflect the modified position

3. Modify SRP 6.2.2 to reflect modified position